USE OF DIPHENYLAMINE (DPA) TO IMPROVE POST-STORAGE QUALITY OF BARTLETT PEARS

Report for the California Pear Advisory Board
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Summary
Bartlett pear fruit were harvested from Lake County at 17 and 14.5 pounds-force. Subsets of fruit were immersed in DPA solution for 2 minutes. The concentrations tested were 0, 500, 1000, 1500, 2000, and 2500ppm. After drying, fruit were placed into boxes in cold storage. Fruit were evaluated after 4 and 5 months of cold storage and again after 5 days of ripening. For the first harvest, after 4 months DPA treated fruit were slightly more firm and had less superficial scald. After 5 days ripening, DPA treated fruit had less superficial scald than control fruit. For the second harvest, DPA treated fruit had significantly less senescent scald compared with untreated control fruit and DPA controlled internal breakdown in fruit storage 4 months but provided only partial control in fruit stored 5 months. Future studies will focus on shorter storage periods.

Introduction
Pear fruit often develop scald after three or more months of cold storage. Bartlett pear is not as susceptible to superficial scald, but Bartlett pears grown in California can develop this disorder due to the hot, dry climate in which they are grown. Bartlett pears also develop senescent scald when they reach the end of their storage life (usually around 4 months) and this is usually accompanied by internal breakdown of the flesh as well. Superficial scald can be controlled by applying antioxidant treatments before cold storage; however, these treatments generally do not affect the incidence of senescent scald. In the Pacific Northwest, ethoxyquin, an antioxidant, is routinely used on pear fruit to control scald. Diphenylamine is routinely used on apples in the Pacific Northwest and in California to control superficial scald on apple fruit. Diphenylamine has been reported to cause phytotoxicity to pear fruit and has not been regularly used on pear. Neither antioxidant material has been available for use on California pear fruit; however, diphenylamine was recently registered for use on pears in the U.S. and could be registered in California as well. In 2005, we tested the effect of diphenylamine on Bartlett pear fruit at a reduced concentration compared to that recommended for apple and completely controlled superficial scald with no phytotoxicity. However, given reports in the literature of phytotoxicity to pears with diphenylamine, we felt we should conduct a more complete test to determine the optimum concentration to control scald without risk of injury.

Methods
Fresh, commercially harvested and packed, size 90 pears were obtained at two different harvest maturities (17 pounds-force and 14.5 pounds-force) from a packinghouse in Finley, CA (Lake County). The first maturity was obtained on August 9, the second on

August 21, 2007. Fruit were transported to UC Davis and held at room temperature overnight. Firmness, soluble solids content (SSC) and titratable acidity (TA) were measured on a sub-sample of 30 fruit. Three replications of 60 fruit each per treatment were immersed for 2 minutes in a DPA solution of 0, 500, 1000, 1500, 2000 or 2500ppm. They were then placed in single layers on paper until dry. Once dry they were placed into boxes with lids open and cooled overnight at -1C (30F). After cooling, boxes were closed, covered with a perforated plastic bag to reduce water loss and stored for 4 and 5 months at -1C (30F). Immediately after each storage period, fruit were evaluated for scald, phytotoxicity, skin color and firmness (5 fruit per rep for each treatment for color and firmness). The same fruit (30 per rep) were observed again after ripening for 5 days at 20C (68F) for scald, phytotoxicity, skin color (only 10 fruit per rep for Minolta color), firmness and internal breakdown.

Results

For the first harvest, initial firmness was 17 lbf., SSC was 11.9% and TA was 0.234%. For the second harvest, initial firmness was 14.5 lbf. SSC was 12.9% and TA was 0.260%.

After 4 months of cold storage, fruit from the first harvest treated with DPA appeared to be slightly more firm and had less superficial scald, although the incidence of superficial scald was very low (Table 1). After 5 days of ripening, the DPA treated fruit were slightly less yellow and were softer than untreated control fruit. This is likely due to the rubbery nature of the heavily scalded control fruit. DPA significantly reduced the incidence of superficial scald and internal breakdown, and the best control was seen with a concentration of 2000ppm DPA. It was interesting that scald and internal breakdown seemed to increase again as concentration increased beyond 2000ppm

Pears from the second harvest had a much greater susceptibility to senescent scald, with nearly 100% incidence. This made it difficult to assess superficial scald and the lower scores in this defect are likely due to a problem with diagnosis rather than a truly lower incidence. Treatment with DPA reduced the incidence of superficial scald, with concentrations of 2000 and 2500 being most effective. Treatment with DPA at all concentrations greatly reduced the incidence of senescent scald, but 500ppm was best. DPA also reduced the incidence of internal breakdown after 4 months of storage, but incidence was still relatively high after 5 months of storage despite the DPA treatment, with 500 and 2000ppm being most effective.

Future studies should address the potential benefits of DPA treatment for shorter storage times, including possible protection from scuffing injury.

Table 1. Evaluations of fruit from harvest 1 after storage at -1C (30F)

DPA Treatment	Storage Time	Days Ripened	Superficial Scald Incidence (%with any)	Superficial Scald Avg Severity score	Superficial Scald % Area Affected	Senescent Scald Incidence	Senescent Scald Avg Severity score	Senescent Scald % Area Affected	IB Incidence	IB Severity
Control	4 month	0	2.2	0.3	n/a	0.0	0.0	n/a	0.0	0.0
Control	4 month	5	92.2	2.0	29.9	0.0	0.0	0.0	34.4	2.4
Control	5 month	0	32.2	1.3	16.9	0.0	0.0	0.0	0.0	0.0
Control	5 month	5	96.7	2.9	46.5	2.2	1.7	20.0	86.7	2.8
500 ppm	4 month	0	1.1	0.3	n/a	0.0	0.0	n/a	0.0	0.0
500 ppm	4 month	5	38.9	1.4	6.8	0.0	0.0	0.0	20.0	1.9
500 ppm	5 month	0	1.1	0.3	5.0	0.0	0.0	0.0	0.0	0.0
500 ppm	5 month	5	50.0	2.2	24.4	0.0	0.0	0.0	57.8	2.6
1000 ppm	4 month	0	1.1	0.3	n/a	0.0	0.0	n/a	0.0	0.0
1000 ppm	4 month	5	35.6	1.5	6.4	0.0	0.0	0.0	15.6	1.3
1000 ppm	5 month	0	5.6	0.3	2.7	0.0	0.0	0.0	0.0	0.0
1000 ppm	5 month	5	70.0	2.5	28.3	0.0	0.0	0.0	78.9	2.7
1500 ppm	4 month	0	0.0	0.0	n/a	0.0	0.0	n/a	0.0	0.0
1500 ppm	4 month	5	26.7	1.3	3.8	0.0	0.0	0.0	17.8	1.4
1500 ppm	5 month	0	1.1	0.3	3.3	0.0	0.0	0.0	0.0	0.0
1500 ppm	5 month	5	37.8	2.4	29.9	1.1	1.0	8.3	76.7	2.5
2000 ppm	4 month	0	1.1	0.3	n/a	0.0	0.0	n/a	0.0	0.0
2000 ppm	4 month	5	14.4	1.1	3.2	0.0	0.0	0.0	6.7	1.0
2000 ppm	5 month	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000 ppm	5 month	5	33.3	2.2	24.9	0.0	0.0	0.0	55.6	2.0
2500 ppm	4 month	0	2.2	0.7	n/a	0.0	0.0	n/a	0.0	0.0
2500 ppm	4 month	5	20.0	1.5	3.5	0.0	0.0	0.0	14.4	2.0
2500 ppm	5 month	0	1.1	0.3	1.7	0.0	0.0	0.0	0.0	0.0
2500 ppm	5 month	5	36.7	2.2	22.4	0.0	0.0	0.0	68.9	2.5

Scald and IB scores: 0 = none; 1 = slight; 2 = moderate; 3 = severe.

Table 2. Evaluations of fruit from harvest 2 after storage at -1C (30F).

DPA Treatment	Storage Time	Days Ripened	Superficial Scald Incidence (%w/any)	Superficial Scald Av Severity score	Superficial Scald % Area Affected	Senescent Scald Incidence	Senescent Scald Av Severity score	Senescent Scald % Area Affected	IB Incidence	IB Severity
Control	4 month	0	1.1	0.3	5.0	70.0	2.7	67.9	0.0	0.0
Control	4 month	5	22.2	1.8	24.7	80.0	2.9	80.9	91.1	2.8
Control	5 month	0	0.0	0.0	0.0	98.9	2.9	92.6	0.0	0.0
Control	5 month	5	1.1	0.3	1.7	97.8	3.0	93.7	98.9	3.0
500 ppm	4 month	0	0.0	0.0	3.3	1.1	0.3	3.3	0.0	0.0
500 ppm	4 month	5	6.7	0.7	4.3	1.1	0.7	3.3	2.2	1.0
500 ppm	5 month	0	4.4	0.3	1.5	5.6	0.7	5.0	0.0	0.0
500 ppm	5 month	5	30.0	2.1	19.4	16.7	1.0	10.7	61.1	2.2
1000 ppm	4 month	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000 ppm	4 month	5	3.3	0.8	7.5	3.3	0.8	7.5	14.4	1.5
1000 ppm	5 month	0	0.0	0.0	0.0	17.8	2.6	43.6	0.0	0.0
1000 ppm	5 month	5	16.7	2.4	21.9	28.9	2.9	38.4	67.8	2.2
1500 ppm	4 month	0	0.0	0.0	0.0	1.1	1.0	6.7	0.0	0.0
1500 ppm	4 month	5	6.7	1.0	11.3	6.7	0.9	10.6	26.7	2.0
1500 ppm	5 month	0	4.4	0.7	2.9	28.9	3.0	57.6	0.0	0.0
1500 ppm	5 month	5	21.1	2.5	22.9	35.6	2.9	66.4	85.6	2.3
2000 ppm	4 month	0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.0
2000 ppm	4 month	5	0.0	0.0	0.0	0.0	0.0	0.0	3.3	1.5
2000 ppm	5 month	0	0.0	0.0	0.0	13.3	1.8	19.5	0.0	0.0
2000 ppm	5 month	5	5.6	1.1	16.7	26.7	2.4	32.9	68.9	2.3
2500 ppm	4 month	0	0.0	0.0	0.0	2.2	2.0	33.3	2.2	2.0
2500 ppm	4 month	5	0.0	0.0	0.0	5.6	1.7	33.1	8.9	1.8
2500 ppm	5 month	0	0.0	0.0	0.0	25.6	2.9	41.1	0.0	0.0
2500 ppm	5 month	5	3.3	1.7	6.7	36.7	3.0	46.5	74.4	2.4

Scald and IB scores: 0 = none; 1 = slight; 2 = moderate; 3 = severe.

Table 3. Color and firmness averages for harvest 1 fruit.

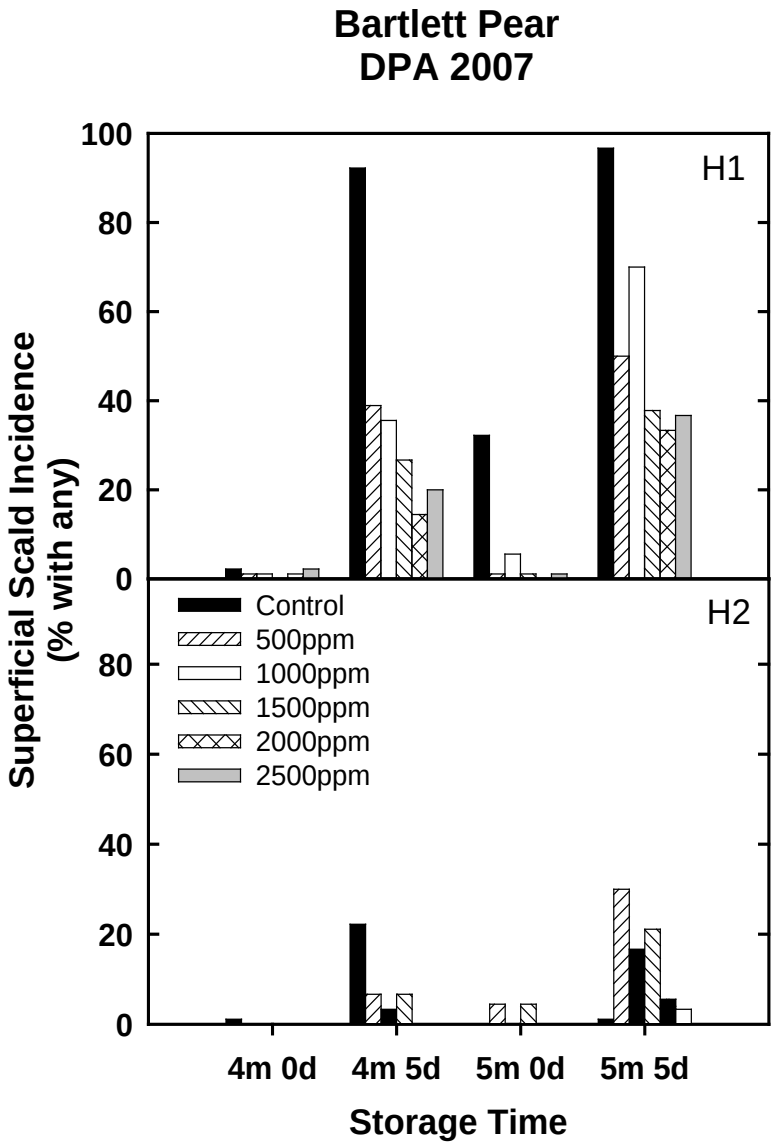
DPA Treatment	Storage Time	Days Ripened	Ground Color	Firmness (lbf)	Minolta color reading				
					L	a	b	C	H
Control	4 month	0.0	2.4	12.7	72.9	-8.8	43.2	44.1	101.6
Control	4 month	5.0	3.8	3.1	74.6	-1.1	46.3	46.3	91.4
Control	5 month	0.0	2.8	11.9	73.7	-5.2	43.2	43.6	96.8
Control	5 month	5.0	4.0	4.0	75.6	0.0	45.1	45.2	90.0
500 ppm	4 month	0.0	2.3	12.8	72.2	-7.9	43.3	44.2	100.4
500 ppm	4 month	5.0	3.8	2.8	75.4	-1.3	46.4	46.4	91.6
500 ppm	5 month	0.0	2.7	12.1	74.0	-6.3	42.9	43.5	98.4
500 ppm	5 month	5.0	3.9	3.5	76.7	-1.3	45.5	45.5	91.7
1000 ppm	4 month	0.0	2.3	13.7	71.9	-8.9	43.3	44.2	101.6
1000 ppm	4 month	5.0	3.8	2.7	71.3	-1.6	44.5	44.5	92.0
1000 ppm	5 month	0.0	2.9	10.9	73.8	-4.5	44.3	44.6	95.8
1000 ppm	5 month	5.0	3.9	3.1	76.7	-1.6	44.8	44.9	92.0
1500 ppm	4 month	0.0	2.3	13.9	72.2	-8.1	42.9	44.1	100.5
1500 ppm	4 month	5.0	3.8	2.5	75.6	-1.7	46.0	46.1	92.0
1500 ppm	5 month	0.0	3.1	11.9	74.3	-6.0	43.6	44.1	97.9
1500 ppm	5 month	5.0	3.9	2.9	76.5	-1.0	45.4	45.4	91.3
2000 ppm	4 month	0.0	2.3	14.1	72.8	-9.7	43.7	44.8	102.4
2000 ppm	4 month	5.0	3.7	2.3	75.8	-2.8	46.6	46.8	93.4
2000 ppm	5 month	0.0	2.6	11.5	72.5	-7.5	43.3	44.1	99.9
2000 ppm	5 month	5.0	3.8	2.6	76.0	-1.6	45.5	45.6	92.0
2500 ppm	4 month	0.0	2.4	13.5	72.5	-8.5	43.5	44.5	100.9
2500 ppm	4 month	5.0	3.7	2.2	75.5	-2.1	46.8	46.9	92.5
2500 ppm	5 month	0.0	2.7	12.4	73.1	-7.2	43.7	44.4	99.4
2500 ppm	5 month	5.0	3.8	2.7	76.4	-1.7	45.6	45.7	92.1

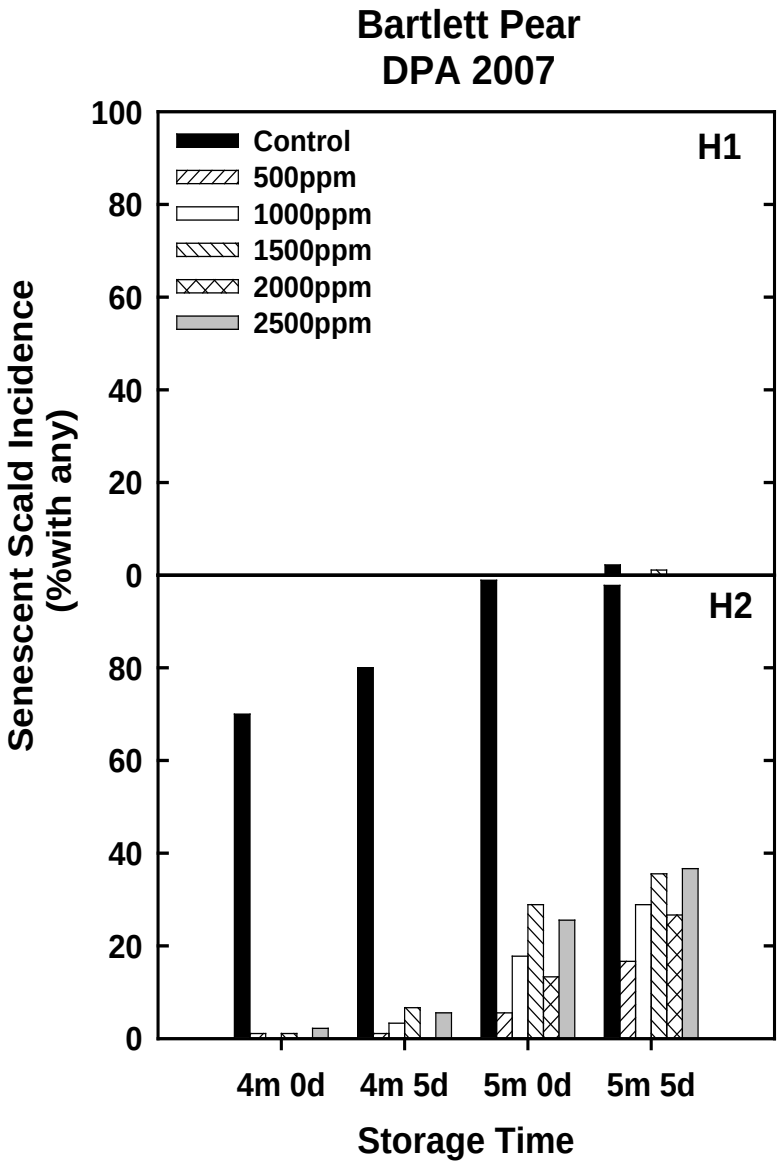
Ground color scores: 1 = green; 2 = light green; 3 = light yellow; 4 = yellow.

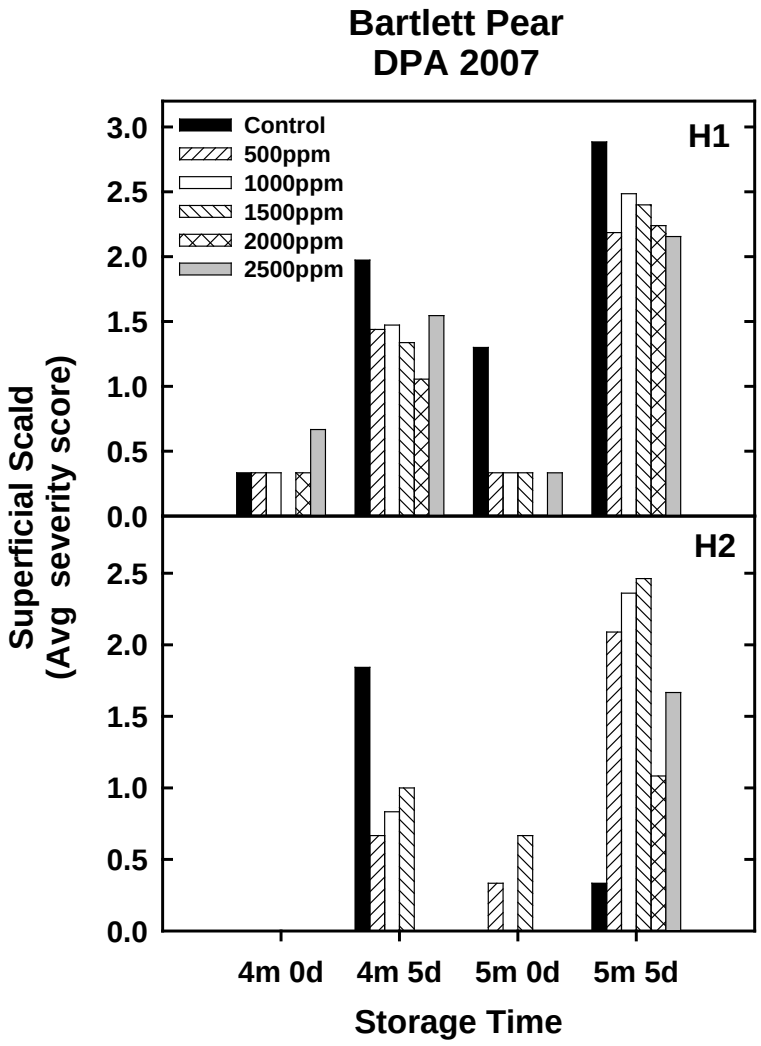
Table 4. Color and firmness averages for harvest 2 fruit.

DPA Treatment	Storage Time	Days Ripened	Ground Color	Firmness (lbf)	Minolta color reading				
					L	a	b	C	H
Control	4 month	0.0	3.3	9.4	74.7	-4.8	41.4	41.7	96.5
Control	4 month	5.0	3.8	4.9	74.7	-2.0	41.1	41.2	92.7
Control	5 month	0.0	3.8	*	75.4	-2.2	42.1	42.2	93.1
Control	5 month	5.0	4.0	*	*	*	*	*	*
500 ppm	4 month	0.0	2.3	13.0	72.3	-9.3	42.4	43.5	102.3
500 ppm	4 month	5.0	3.9	2.9	76.2	-3.8	43.3	43.5	95.0
500 ppm	5 month	0.0	2.8	10.6	74.3	-6.9	42.6	43.2	99.1
500 ppm	5 month	5.0	3.9	3.5	75.1	-2.1	42.9	42.9	92.8
1000 ppm	4 month	0.0	2.6	11.4	74.0	-7.1	42.8	43.4	99.3
1000 ppm	4 month	5.0	3.9	3.0	76.5	-3.2	42.9	43.0	94.2
1000 ppm	5 month	0.0	3.1	9.9	76.1	-5.3	42.3	42.7	97.1
1000 ppm	5 month	5.0	4.0	4.0	75.5	-1.9	42.4	42.4	92.6
1500 ppm	4 month	0.0	3.0	10.2	74.1	-7.0	41.9	42.5	99.4
1500 ppm	4 month	5.0	3.8	3.2	76.4	-2.8	43.0	43.1	93.7
1500 ppm	5 month	0.0	3.2	9.4	76.0	-4.2	42.6	42.8	95.6
1500 ppm	5 month	5.0	3.9	4.1	76.0	-1.7	42.7	42.8	92.3
2000 ppm	4 month	0.0	2.6	11.3	72.5	-8.1	42.5	43.4	100.8
2000 ppm	4 month	5.0	3.9	2.6	76.5	-3.3	43.1	43.3	94.3
2000 ppm	5 month	0.0	2.9	9.2	75.7	-4.5	42.6	42.8	96.0
2000 ppm	5 month	5.0	3.8	3.5	75.8	-2.3	42.7	42.7	93.1
2500 ppm	4 month	0.0	2.8	10.9	73.8	-7.0	41.4	42.1	99.5
2500 ppm	4 month	5.0	3.9	2.8	76.6	-3.2	43.4	43.5	94.3
2500 ppm	5 month	0.0	3.0	8.9	75.6	-5.1	42.6	43.0	96.8
2500 ppm	5 month	5.0	3.7	3.7	76.3	-2.3	42.5	42.6	93.1

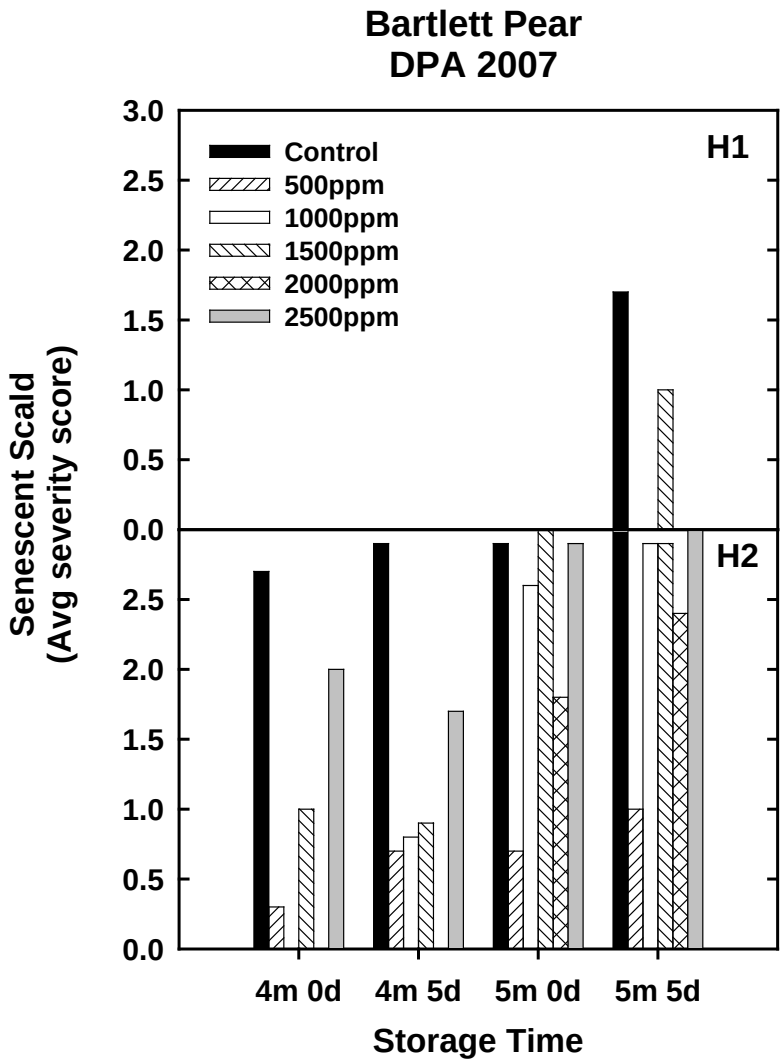
- no readings taken because scald on fruit was too severe.


Bartlett Pear
DPA 2007
Superficial Scald Incidence
(% with any)
H1
H2
Control
500ppm
1000ppm
1500ppm
2000ppm
2500ppm
0
20
40
60
80
100
4m 0d
4m 5d
5m 0d
5m 5d
Storage Time

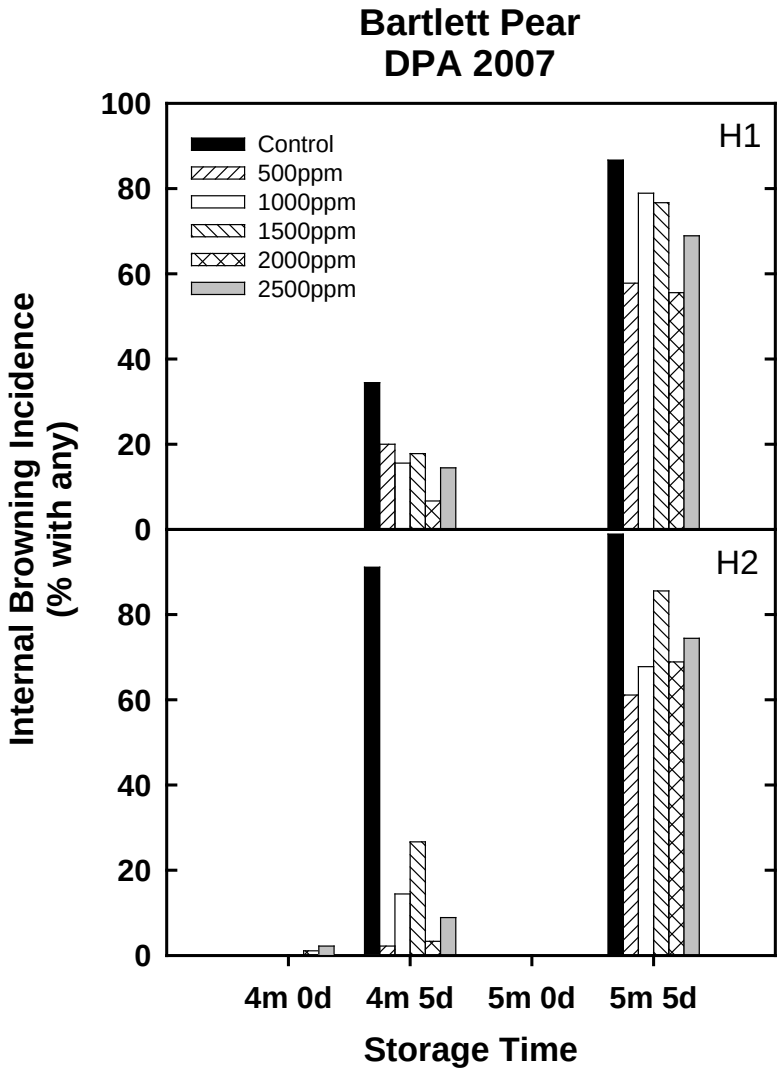

Bartlett Pear
DPA 2007
Senescent Scald Incidence
(%with any)
H1
H2
Control
500ppm
1000ppm
1500ppm
2000ppm
2500ppm
0
20
40
60
80
100
4m 0d
4m 5d
5m 0d
5m 5d
Storage Time

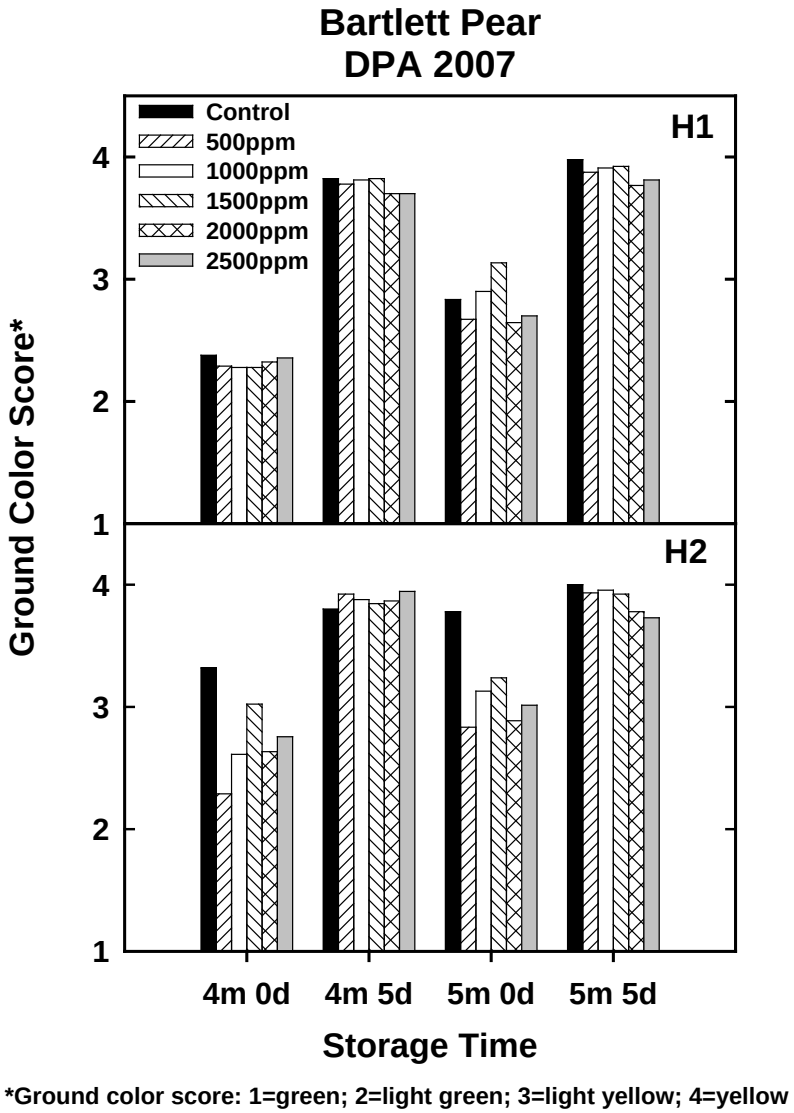


Superficial Scald score: 0=none; 1=slight; 2=moderate; 3=severe

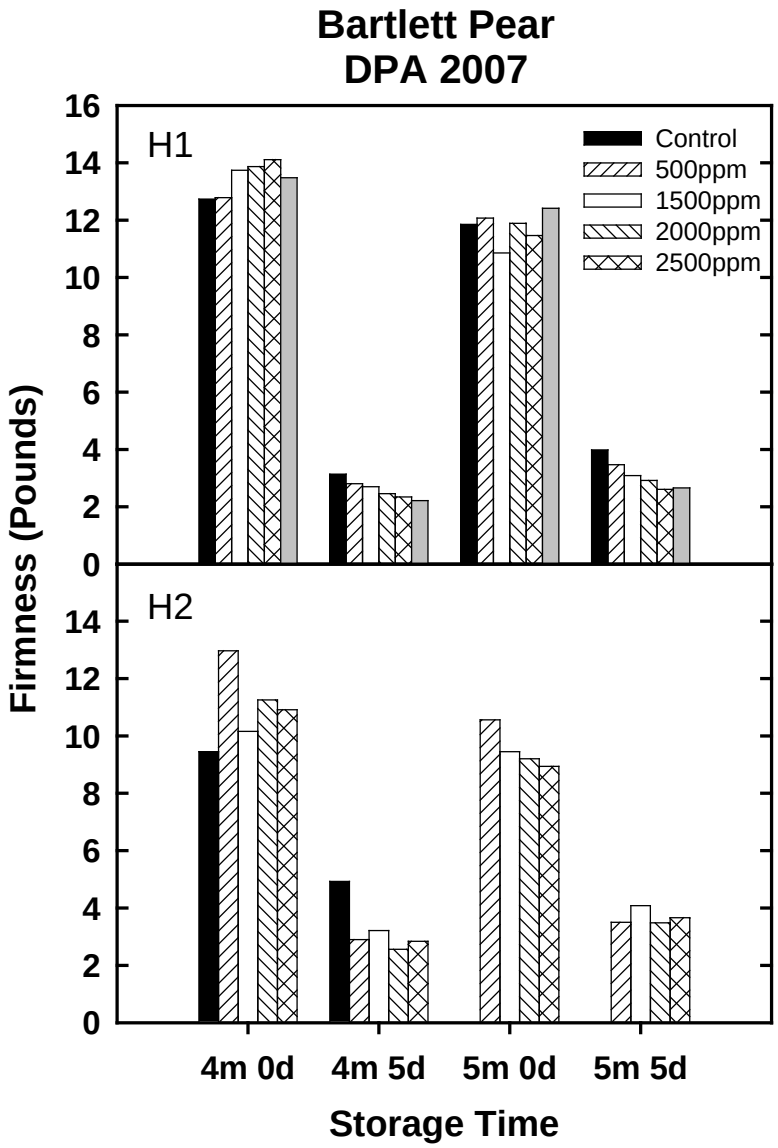


Senescent score: 0=none; 1=slight; 2=moderate; 3=severe





*Ground color score: 1=green; 2=light green; 3=light yellow; 4=yellow


Bartlett Pear
DPA 2007
H1
H2
Control
500ppm
1500ppm
2000ppm
2500ppm
Firmness (Pounds)
0
2
4
6
8
10
12
14
16
4m 0d
4m 5d
5m 0d
5m 5d
Storage Time